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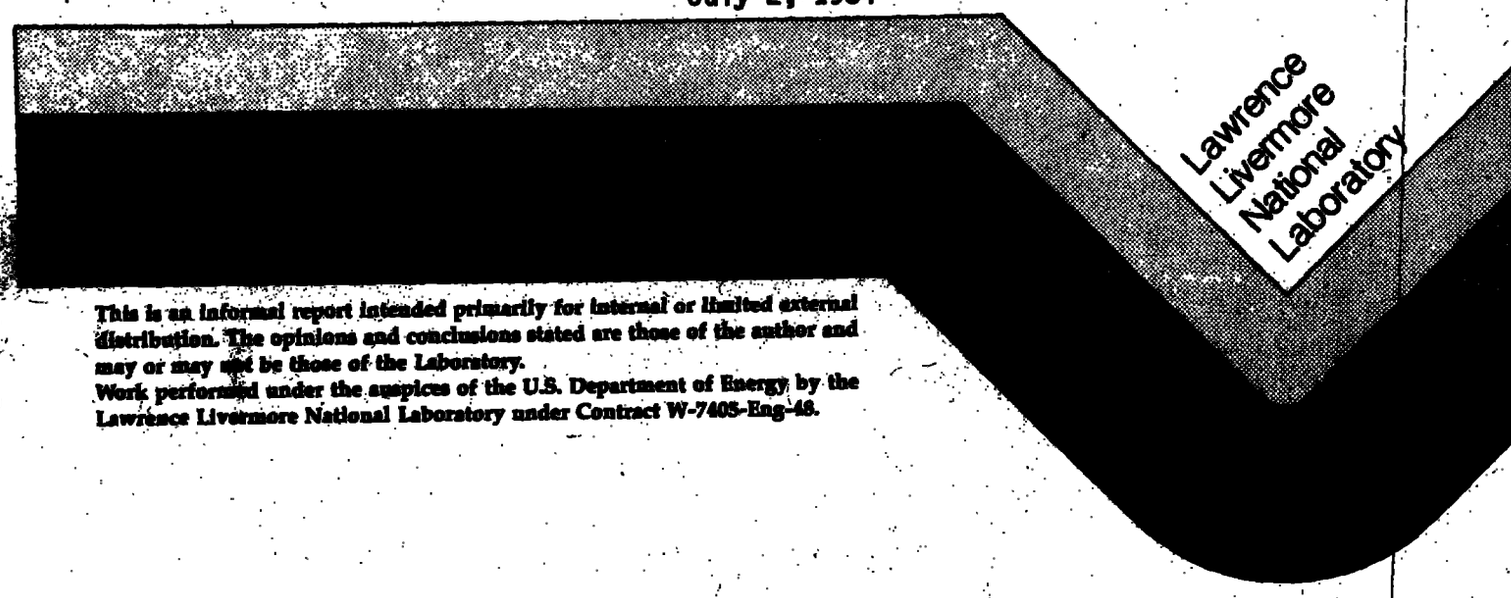
U. S. ENERGY FLOW - 1983

C. K. Briggs
I. Y. Borg

July 2, 1984



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ABSTRACT

Energy use in 1983 closely paralleled 1982 consumption of 70 quads (70 x 10^{15} Btu) although industrial production and GNP were up 6.5% and 3.3% respectively in 1983 and 1982 was clearly a recession year. Domestic oil production as well as crude imports closely resembled those of 1982. The ratio between energy use (in quads) and GNP (in 1972 dollars) also declined suggesting the continuing importance of conservation. Coal production fell slightly reflecting loss of exports due to strong foreign competition as well as smaller foreign markets. Natural gas sales fell substantially (≈ 10%) across all end-use sectors. Price increases to residential, commercial and industrial consumers on the order of 15% were recorded and influenced fuel-switching although on a Btu basis only high sulfur residual oil is cost competitive with natural gas and then only for large industrial and utility users.

INTRODUCTION

United States Energy Flow Charts tracing primary resource supply and end-use have been prepared by members of the Energy and Resource Planning Group at the Lawrence Livermore National Laboratory since 1972.[1,2] They are convenient graphical devices to show relative size of energy sources and end-uses since all fuels are compared on a common Btu basis. The amount of detail on a flow chart can vary substantially, and there is some point where complexity begins to interfere with the main objectives of the presentation. The charts shown here have been drawn so as to remain clear and be consistent with assumptions and style used previously.

ENERGY FLOW CHARTS

Figures 1 and 2 are energy flow charts for calendar years 1983 and 1982[3], respectively.

Data for the flow chart were provided by tables in the Department of Energy Monthly Energy Review, DOE/EIA-0035[4], the 1983 Annual Energy Review[5] and the Quarterly Coal Report, DOE/EIA-0121.[6]

The Residential and Commercial Sector consists of housing units, non-manufacturing business establishments, health and educational institutions, and government office buildings. The Industrial Sector is made up of construction, manufacturing, agriculture, and mining establishments. The Transportation Sector combines private and public passenger and freight transportation and government transportation including military operations.

U.S. ENERGY FLOW — 1983
(NET PRIMARY RESOURCE CONSUMPTION 70 QUADS)

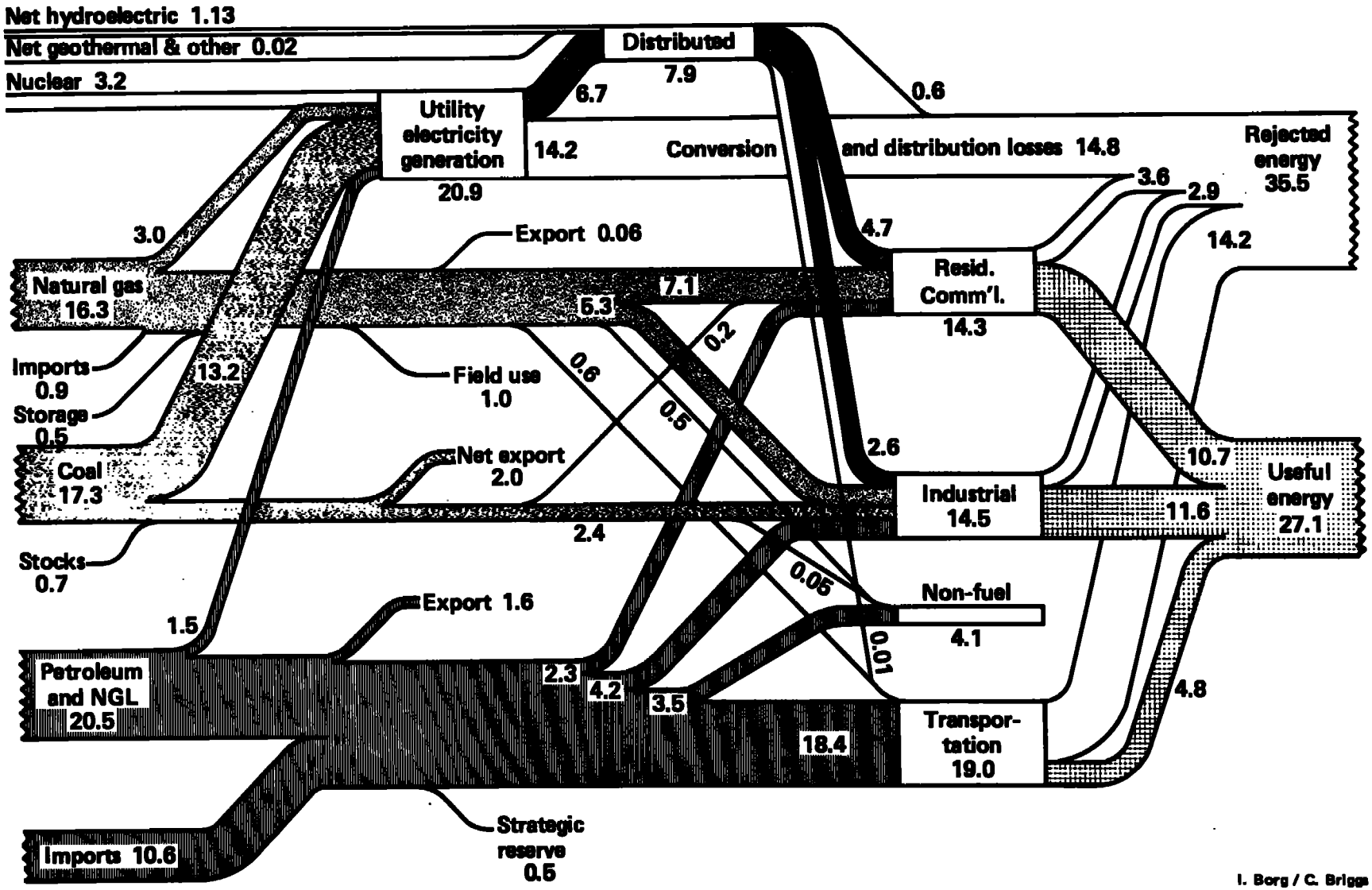
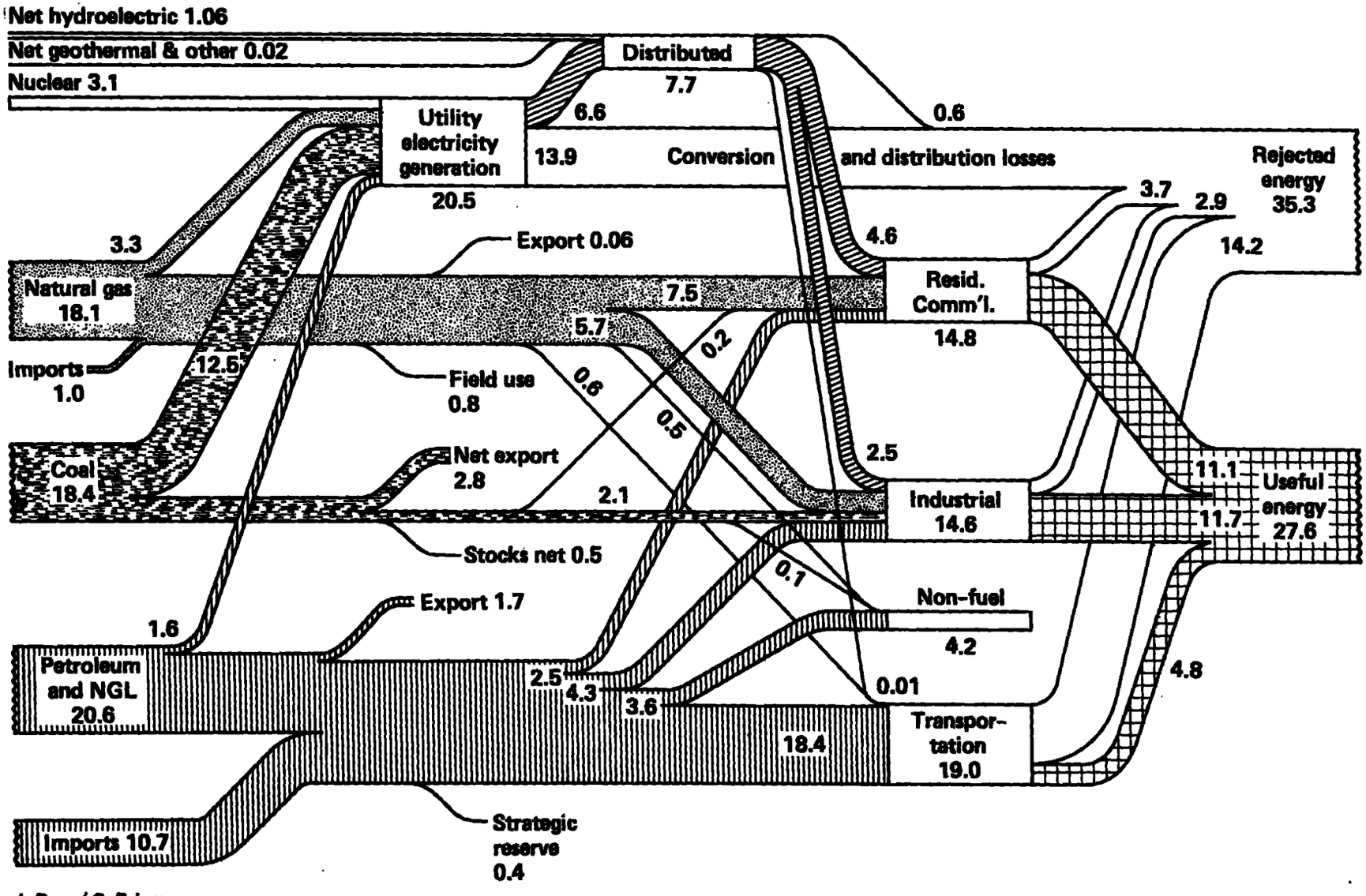


Figure 1

U. S. ENERGY FLOW — 1982
(NET PRIMARY RESOURCE CONSUMPTION 70 QUADS)



I. Borg / C. Briggs

Figure 2

Utility electricity generation includes power sold by both privately and publicly owned establishments. The non-fuel category of end-use consists of fuels that are not burned to produce heat, e.g., asphalt, road oil, petrochemical feedstocks such as ethane, liquid gases, lubricants, petroleum coke, waxes, carbon black and crude tar. Coking coal traditionally is not included. The appendix lists conversion factors used in converting fuel quantities to Btu.

The division between "useful" and "rejected" energy is arbitrary and depends on assumed efficiencies of conversion processes. In the residential and commercial end-use sectors, a 75 percent efficiency was assumed which is a weighted average between space heating at approximately 60 percent and electrical lighting and other electrical uses at about 90 percent. Eighty percent efficiency was assumed in the industrial end-use sector and 25 percent in transportation. The latter percent corresponds to the approximate efficiency of the internal combustion engine.

COMPARISON WITH 1982 AND PAST YEARS

Figures 1 and 2 provide graphic comparison energy use for 1983 and 1982. The breakdown of energy usage used here is based on preliminary data from DOE. For comparison, Table 1 lists the consumption of energy resources in the United States for the past seven years. The data in Table 1 reflect substantial revisions in historical data reported by DOE (see Monthly Energy Review, March 1983, p. 36 for explanation). There are some differences between data on total energy consumption and data presented in Table 1 and

TABLE 1. COMPARISON OF ANNUAL ENERGY USE IN U. S.

	Quads						
	1977	1978	1979	1980	1981	1982	1983
Natural gas	19.57	19.49	20.08	19.91	19.70	18.26	16.34
Imports	1.01	0.97	1.25	0.99	0.90	0.93	0.94
Crude oil and NGL							
Domestic crude & NGL	19.78	20.68	20.39	20.50	20.45	20.50	20.53
Foreign imports (incl. products & SPR)	18.64	17.70	17.90	14.63	12.69	10.82	10.56
Exports	0.51	0.77	1.00	1.15	1.26	1.73	1.56
SPR storage reserve*	0.04	0.34	0.14	0.10	0.71	0.37	0.49
Net use (minus exports and SPR)	37.87	37.27	37.15	33.89	31.17	29.22	29.04
Coal (incl. exports)	15.68	14.86	17.48	18.54	18.33	18.60	17.29
Electricity							
Hydroelectric (utility) (net only)	0.75	0.96	0.95	0.94	0.89	1.06	1.13
Geothermal & other (net only)	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Nuclear	2.70	3.02	2.78	2.74	3.01	3.12	3.22
Gas	3.28	3.30	3.61	3.81	3.76	3.34	3.01
Coal	10.24	10.24	11.26	12.12	12.58	12.58	13.23
Oil	3.90	3.99	3.28	2.63	2.20	1.57	1.54
Total fuel	20.88	21.52	21.90	22.26	22.46	21.69	22.15
Total transmitted energy	7.25	7.53	7.67	7.80	7.83	7.65	7.88
Residential and Commercial	15.84	16.03	15.71	15.09	14.55	14.64	14.29
Industrial	24.50	24.45	25.53	23.79	22.50	19.98	19.55
Transportation	19.78	20.57	20.44	19.67	19.47	19.04	18.97
Total consumption** (DOE/EIA)	76	78	79	76	74	71	70

* Strategic petroleum reserve storage began in October, 1977.

**Note that this total is not the sum of entries above.

Source: Monthly Energy Review DOE/EIA-0035 (83/12[4]). Revised data as of March 1984.
Some figures differ from those on earlier flow charts.

Figure 1 due to our conventions relating to consumption that exclude coal stocks and oil put into the Strategic Petroleum Reserve. Further, hydropower is given by DOE in gross quads (10^{15} Btu) whereas it is listed as a net input in Figs. 1 and 2. Thus the sum of inputs and end uses of energy shown in Figs. 1 and 2 must also be increased by about 2.7 Quads in order to reflect hydropower losses of various sorts and to agree with DOE totals of 70Q and 71Q.

In most respects energy patterns and use were similar in 1982 and 1983. For the sixth consecutive year net oil use declined in the U. S. although in 1983 the decline was trivial. Substantial declines between 6.4 and 8.6% occurred in the 1980-82 period. Almost all of the drop was in foreign imports (Fig. 3). Domestic oil production for all purposes has been stable for the past four years. In 1983 as in the previous six years, the principal oil product whose use fell was residual oil (Table 2) and to a lesser extent distillate oil. Both fuels are being affected by fuel switching on the part of the utilities to coal and in California to natural gas. In 1983 OPEC finally officially lowered crude oil prices (Fig. 4)[7]; however, even with depressed prices for crude oil, prices of petroleum products remained much higher than alternate hydrocarbon fuels when compared on a Btu basis.

The Strategic Petroleum Reserve rose to 379 million barrels from 294 million at the end of 1982, the bulk of it from, the United Kingdom and Mexico [8]. A dramatic shift in the source of all U. S. oil imports began in 1982. By year-end 1983 OPEC sources accounted for only 44% of total imported volumes[9]. In 1981 OPEC had averaged 66.3% of U. S. supply with Saudi Arabia accounting for 25% of total imports. In 1983, Mexico was the U. S.'s largest single supplier and the North Sea (U.K. and Norway) respective averages for the year were 22% (Mexico) and 12% (North Sea).[9]

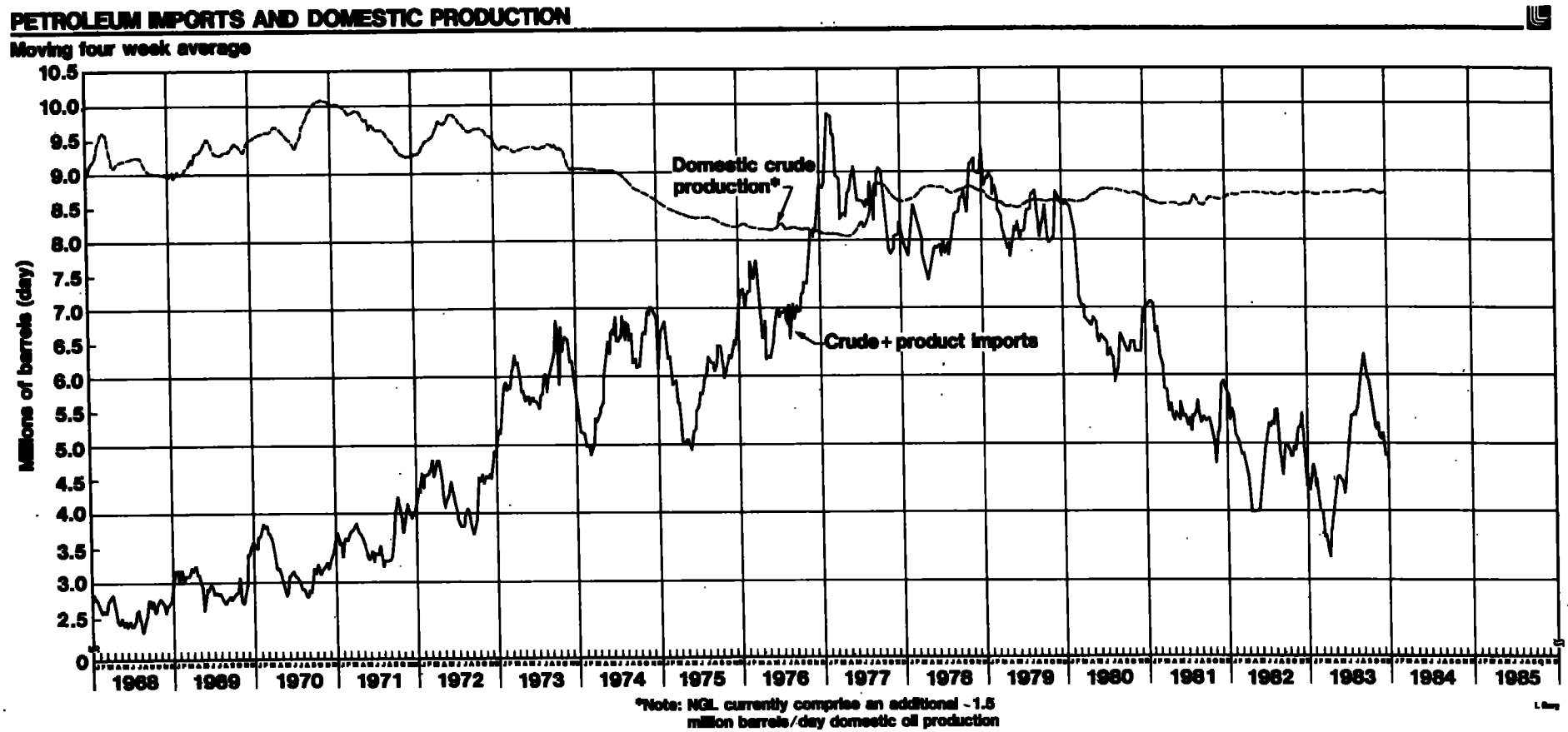

PETROLEUM IMPORTS AND DOMESTIC PRODUCTION
Moving four week average
Millions of barrels/day
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
0
Domestic crude production*
Crude + product imports
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
*Note: NGL currently comprise an additional ~1.5 million barrels/day domestic oil production

Figure 3

TABLE 2. PETROLEUM PRODUCTS.*

	10^3 Barrels/Day (Average)							
	1976	1977	1978	1979	1980	1981	1982	1983
Motor gasoline	6,978	7,177	7,412	7,034	6,579	6,588	6,539	6,617
Jet fuel	987	1,039	1,057	1,076	1,069	1,011	1,010	1,040
Distillate fuel oil	3,133	3,352	3,432	3,311	2,866	2,829	2,671	2,682
Residual fuel oil	2,801	3,071	3,023	2,826	2,508	2,088	1,716	1,403

*Refined petroleum product supplied: sum of production, imports, net withdrawals from primary stocks minus exports.

Source: Monthly Energy Review, DOE/EIA-0035 (83/12[4]); 1983 Annual Energy Review, DOE/EIA-0384 (82) April 1984.

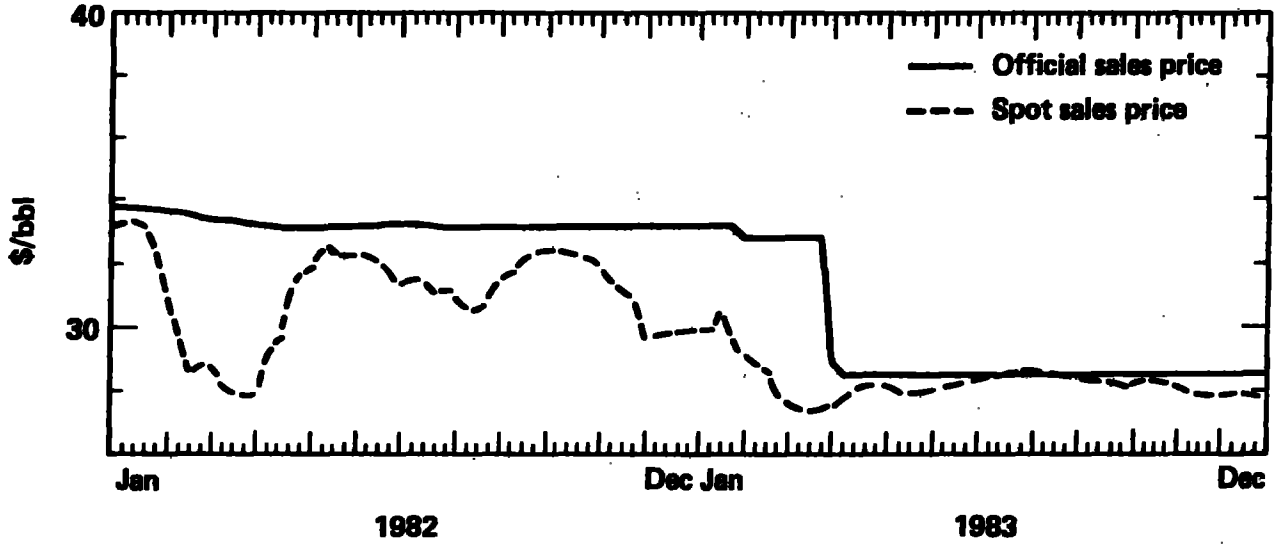

40
30
$/bbl
Official sales price
Spot sales price
Jan
Dec Jan
Dec
1982
1983

Figure 4.

Natural gas saw decreased use in 1983. Decline was evident in all major end use sections. The gas industry attributed limited sales to low oil prices, warm weather and "business conditions".[10] However, 1983 was a recovery year, and the somewhat warmer than normal 1982-3 heating season was offset by a cooler 1983-4 heating season.[11] Other observers believe pricing policies have held up sales.[12] The average well head price of gas was $2.60 per thousand cubic feet, up from $2.46 in 1982. Average industrial and residential prices were up 14 and 16%, respectively, in the same period. Even at levels of $4.25 to $6.00, natural gas was cheaper than high grade petroleum products when compared on a Btu basis.

The volume of coal produced in 1983 was 7% below 1982 levels. (Table 1). Demand for coking coal in domestic and foreign markets fell reflecting the world wide recession and drop in steel production. Strong competition from other coal exporting countries also affected U. S. coal exports.

Total transmitted electrical energy has remained nearly constant since 1980. Fuels burned for power generation continued to be dominated by coal (60%). With falling oil prices fuel switching to coal has slowed somewhat. The continuing recession has similarly affected plans to retrofit oil and gas burning electrical generating equipment to burn coal; nonetheless, the small increase in transmitted electrical power can be attributed to new enlarged coal burning plants. Nuclear power provided 14.5% of domestic electrical generation - a slight increase over 1982 operations. There were 83 licensed nuclear reactors (3 in start-up)* with an operating capacity of $\sim$ 63 GW_e.

*Excludes reactors at Peach Bottom-1, Indian Point-1, Humboldt, CA., Dresden-1, and one reactor at Three-Mile Island.

The 1983 situation reflects the licensing during the year of 4 additional reactors with 3 GW_e available capacity. At year-end there were two reactor units on order, thus the situation is unchanged since January 1982.

1983 - A Recovery Year

By most measures the U. S. economy made a steady recovery throughout 1983 from the 1982 recession year. GNP rose 3.3% and industrial production as measured by the index published by the Federal Reserve Board was up 6.5% for the year. Unemployment fell from a 40 year high of 10.7% at the beginning of 1983 to 8% at the end.[13] Nonetheless, total energy consumption in the nation (70 quads) differed insignificantly from the previous year's total (71 quads). The energy/GNP ratio fell again (Fig. 5). In conjunction with an increase in industrial production, the continued drop suggests that conservation continues to be effective in reducing energy use. The gas to GNP ratio (quads per trillion 1972 dollars) fell much farther than the energy to GNP ratio, which is in keeping with decreased gas consumption in industrial and commercial end-use sectors (compare Figs. 1 and 2). By contrast, oil use in these end-use sectors remained at or a little below 1982 levels, notwithstanding the long-standing decline in residual fuel demand (Table 2) associated with utilities and other users switching to coal.

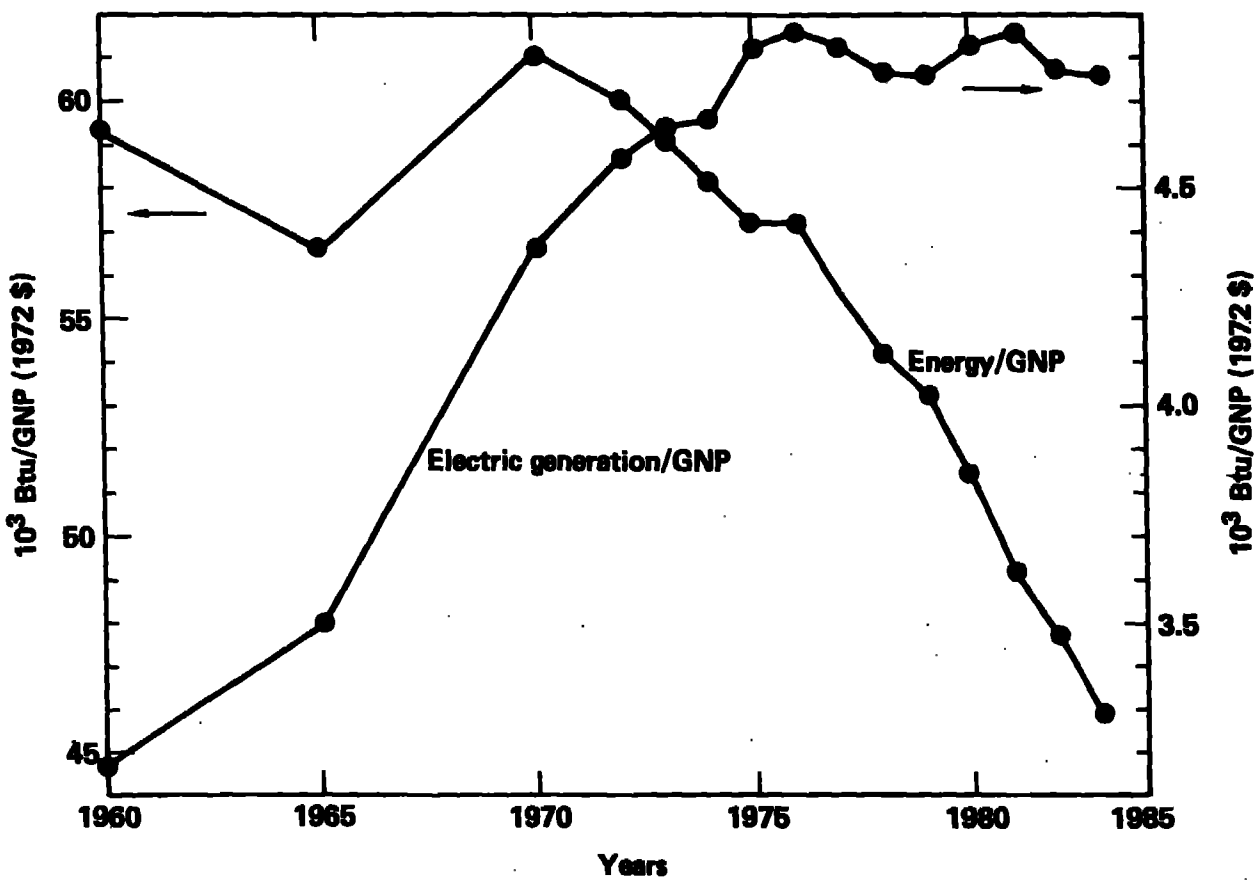

60
55
50
45
4.5
4.0
3.5
10^3 Btu/GNP (1972 $)
10^3 Btu/GNP (1972 $)
Energy/GNP
Electric generation/GNP
1960
1965
1970
1975
1980
1985
Years

Figure 5

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APPENDIX

Conversion Factors

The energy content of fuels varies. Some approximate, rounded conversion factors, useful for estimation, are given below.

Fuel	Energy Content (Btu)
Short ton of coal	22,400,000
Barrel (42 gallons) of crude oil	5,800,000
Cubic foot of natural gas	1,000
Kilowatt hour of electricity	3,400

More detailed conversion factors are given in the Department of Energy's Monthly Energy Review.